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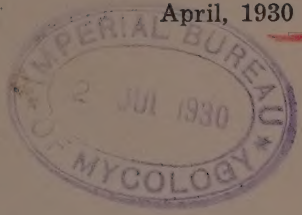

ALFALFA WILT IN NEBRASKA

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SUMMARY

1. Alfalfa wilt, caused by a bacterium (*Aplanobacter insidiosum* L. McC.) was first found in Nebraska in 1925. It should not, however, be considered as a new disease of alfalfa.

2. The disease has been found in one or more fields in all parts of the state, the severity and loss depending upon the conditions under which alfalfa was growing.

3. Losses from wilt are most serious in the irrigated and subirrigated valleys. In the uplands where alfalfa is grown in rotations, the economic losses are not so serious. On the tablelands of western Nebraska, wilt is a negligible factor in stand reduction.

4. The disease can be readily recognized by the dwarfing and yellowing of the plants, the bunch-growth effect produced by the many and shortened stems, the small, chlorotic, rounded, cupped leaves, and finally by the yellow or brown discoloration in the outer bark of the tap root.

5. The reduction in stand due to wilt has been studied by means of six-foot quadrats and the percentage of wilt thru the use of two-foot quadrats. A number of these quadrat studies were made on the alfalfa plats at the Experiment Station at Lincoln and in a number of fields in Buffalo and Dawson counties.

6. The length of life of diseased plants is extremely variable, but the greatest mortality from wilt occurs in the second season after infection, especially when the plants are under great stress during the summer months.

7. Plants are usually attacked at the ages of two years and upward. Infection is rare under field conditions the first year.

8. Infection of the plants is likely to occur twice during the year, (a) in the early spring and (b) in the forepart of June at the time of first cutting. Some infection also occurs during the summer, but rarely in the fall.

9. Entrance of the bacteria into the plants is effected only thru wounds, probably those formed (a) in the early spring thru recently formed winter injury lesions, mostly in the form of cracks, and (b) thru the freshly cut ends of the stems.

10. There are two important means by which the bacteria can be disseminated from plant to plant and field to field, namely surface irrigation and drainage water and the cutting bar of the mower.

11. Studies thus far made indicate that all regional strains of Common alfalfa tested are susceptible to wilt. Grimm is as susceptible as Common alfalfa. Three varieties, Hardistan, Turkestan (three introductions), and Provence (two introductions) appear to be tolerant of or resistant to wilt.

12. The solution of the alfalfa wilt problem in Nebraska lies in the development of resistant varieties. For the present, the following recommendations are offered:

Plant hardy seed of known origin in fields not recently cropped to alfalfa and not adjoining old, diseased fields.

Employ all cultural practices that will insure a vigorous and productive stand.

Avoid cutting too late in the fall.

Mow only when the plants are dry.

Cut all fields separately, preferably beginning operations in the younger and moving to the older fields.

ALFALFA WILT IN NEBRASKA

GEORGE L. PELTIER AND JAMES H. JENSEN[1]

After the disastrous winter of 1917-18 the alfalfa acreage in Nebraska increased rapidly until 1924, when 1,358,000 acres (Fig. 1) were grown, an increase of approximately one-half million acres. A gradual decrease in acreage has since occurred until only 1,095,000 acres of alfalfa were grown in 1929, which is the lowest acreage reported for the state since 1918. A number of factors have been responsible for this decrease of about one-quarter of a million acres, one of which is alfalfa wilt, caused by a bacterium *(Aplanobacter insidiosum* L. McC.) (1, 2). Alfalfa wilt was first observed in Nebraska in 1925, altho evidence is at hand to show that it had been present for a number of years previous, so that it should not be considered as a recently introduced disease of alfalfa.

An investigation of this disease, together with certain other factors involved in alfalfa failures in Nebraska, was undertaken in 1927. While these various studies have not by any means been completed, enough information has been obtained to present a preliminary report on the more important aspects of the disease. The more detailed studies, including the pathological anatomy of the disease and its relation to winter injury, will be reported at a subsequent date.

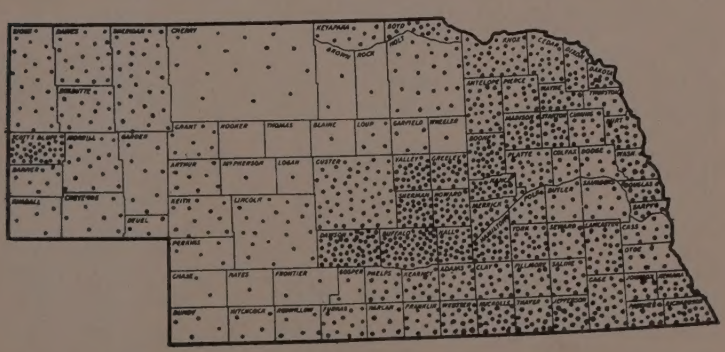

FIG. 1.—Distribution of alfalfa in Nebraska. Each dot represents 1,000 acres grown in 1924. Data from Nebraska Agricultural Statistics for 1924.

[1] Acknowledgment is gratefully made to County Agent Alvah Hecht, to the Farm Bureaus of Buffalo and Dawson counties, and to the many alfalfa growers for the assistance, facilities, and courtesies extended in this investigation.

DISTRIBUTION AND IMPORTANCE OF WILT IN THE VARIOUS ALFALFA GROWING SECTIONS OF NEBRASKA

During the past three years a survey for alfalfa wilt including all parts of the state has been made. Fields of varying ages in all sections have been carefully examined for signs of wilt by observing the above-ground symptoms and by digging the plants and noting the typical root discoloration accompanying this disease. As a result of this survey, wilt was readily found in the one or more fields studied in various localities in the state. However, the amount and importance of wilt found in any one locality depended on the conditions under which alfalfa was grown. These conditions can be roughly classified as follows.

Irrigation. Wilt occurs in practically all fields of alfalfa over two years of age in the irrigated sections of the state. As a rule it appears in small amounts during the second season, but a reduction in stand is not noticeable until the third or fourth year. While wilt is apparently more severe in irrigated fields, the economic loss is not so great as would be expected, owing to the fact that alfalfa is used in rotations and is generally plowed under at the end of the fourth to the sixth year, before its productivity becomes greatly curtailed.

Subirrigation. Alfalfa is grown under subirrigation in most of the valleys in the state. The largest acreages, however, are found in the Platte and Republican valleys. Under these conditions the water tables vary from 5 to 30 feet below the surface of the soil and once the roots reach these levels, water is not the limiting factor in the growth of the plants. In the subirrigated regions the cropping system makes it desirable to maintain productive stands for a long period.

Wilt is generally present in fields under subirrigation. Usually small amounts can be found in two-year-old fields. Losses in stand are rarely noticeable in three-year-old fields. However, many four- and five-year-old fields become so unproductive as to necessitate plowing under. Fields older than five years become increasingly rare, until only an occasional old field can be found. Where alfalfa is grown under subirrigation primarily for hay and where productive stands for an indefinite period are most profitable, wilt is often an important factor in stand and yield reduction the third or fourth year.

Upland (Eastern Nebraska). A large part of the alfalfa acreage in Nebraska is located on the uplands of the eastern half of the state. Under these conditions, altho wilt is a factor in stand reduction, stands rarely become unproductive until

the fifth year or later and at that age they may become unproductive from a combination of several factors.

Tableland (Western Nebraska). On the tablelands of western Nebraska, while wilt is found in some fields, only a few plants are diseased. Wilt is an almost negligible factor in the loss of stands and productivity in this section.

To summarize, altho wilt can be found in some fields in any locality in the state, the amount of wilt and the resultant reduction in stands vary considerably with the type of region in which alfalfa is growing. From an economic standpoint, wilt is an important and serious factor only in the subirrigated valleys, where alfalfa is primarily grown for hay and where a productive stand for an indefinite period is desired. While wilt undoubtedly is responsible for loss of stands and unproductive fields in other parts of the state, the economic loss is not so great where the cropping system includes alfalfa in rotations.

DESCRIPTION OF THE DISEASE

Alfalfa wilt is a disease affecting primarily the young, rapidly growing vascular tissue, altho in the more advanced stages other tissues are attacked, usually resulting in the death of the plants. The diseased plants are characterized by a slow, dwarfed growth of the stems, resulting from impaired water and possibly food conduction. This is the most conspicuous symptom. Usually there is an excessive number of small and shortened stems, giving the plants a bunch-growth effect. The leaves are yellowish and much smaller than healthy ones; they are curled upward and appear cup-shaped. These dwarfed plants are very striking alongside healthy individuals, especially when the new growth is 20 to 30 days old (Fig. 2).

It is only in the advanced stages of the disease, especially during the summer months, that actual wilting is apparent. Wilting of the plants is first recognized by the drooping over of the tips of the stems. Soon afterward a more or less complete wilting or drying up of the entire plant occurs (Fig. 2 D). Owing to the fact that wilting is usually observed at certain times of the year and that plants may die without showing any signs of wilting, whereas dwarfing is always the most conspicuous symptom, bacterial dwarf of alfalfa would be a much more appropriate name for the disease than bacterial wilt.

Diseased plants may show many varied degrees of the above-described symptoms, from an occasional deformed and chlorotic leaf to complete wilting. In slightly diseased plants only one or two stems may be shortened and bear a few small, yellowish and rounded leaves. However, in most fields where

FIG. 2.—Four stages in the symptoms of alfalfa wilt. A.—Healthy. B.—Slight dwarfing and yellowing. C.—Pronounced dwarfing. D.—Wilting.

the disease is prevalent, typical symptoms will be clearly evident on some of the diseased plants.

When plants showing symptoms of the disease, as described above, are dug up and the roots cut across, a characteristic discoloration is always present. This discoloration may be yellow or brown, the extent depending more or less on the severity of the disease. In slightly infected plants the discoloration may be noted as a small, yellow streak just under the bark, which progresses around the outer layer of woody tissue. The discoloration extends down into the tap root and side roots and also the rootlets and up into the crown and into the stems, altho discoloration in the stems is not

always present (Fig. 3). In the roots of many diseased plants, more than one ring of discoloration can be found in the wood. Here infection occurred in previous years but did not kill the plants, so that a second and perhaps a third ring of discoloration appeared as the new wood was laid down each year.

Apparently the disease is not fatal to the plant until the bacteria leave the vascular elements and penetrate into the other tissues. At times the bacteria form quite extensive lesions in the parenchymatous tissue of the outer bark region. These dark or reddish brown lesions can be readily seen when the bark is stripped from the woody cylinder.

To summarize, the disease can be readily recognized in the field by the dwarfing and yellowing of the plants, the bunch-

FIG. 3.—The brown discoloration in the outer part of the wood beneath the bark of the tap root. Figure also shows the typical above-ground symptoms associated with the discoloration. A.—Diseased plant. B.—Healthy plant.

growth effect produced by the many and shortened stems, the small, chlorotic, rounded, cupped leaves, and finally, the yellow or brown discoloration in the outer wood of the tap root.

FIELD STUDIES OF WILT AT LINCOLN

Most of the wilt studies at Lincoln were made in the alfalfa plats grown by the Agronomy Department at the Experiment Station. This field is representative of the uplands typical of the eastern half of the state. Two agronomic reports have been published by Kiesselbach and Anderson (3, 4) on the data obtained from these test plats, so that no details of these plantings need be mentioned here other than to state that they were seeded in the spring of 1922.

Wilt was first pointed out in these plats in the spring of 1925 by Dr. F. R. Jones. At that time only a few diseased plants were found. The next spring it was much easier to find infected plants, and by 1927, when wilt studies were undertaken, the disease was quite prevalent over the whole field.

In order to determine roughly the percentage of infected individuals in the field as a whole, a number of plants were dug up in 1928 in various parts of each of the check plats (Nebraska Common), every fifth plat being a check. The average infection in all the check plats was 80 per cent. Wilt was, therefore, generally distributed over the field.

To ascertain the loss of stand, permanent six-foot quadrats (areas of 36 square feet) were staked out in the most representative section of each of a number of the plats. When the new growth, either in the spring or after mowing, was about six inches high, all of the plants in each quadrat were charted. The dead or missing plants with their exact locations could thus be recorded from one season to another. The loss of stand in these quadrats was the result of all factors involved in the death of the plants, including, of course, winter injury and wilt. Charting of these permanent quadrats was done in October of 1927 and again in May, 1928.

As the permanent quadrats did not give any clue to the actual percentage of plants infected with wilt, two-foot quadrats (areas of four square feet) were dug in the vicinity of the larger ones at various intervals and notes taken on the total number of plants, their general conditions, number infected with wilt, and the severity of wilt. Thus, a fairly good idea of the amount and severity of wilt was obtained and an estimation of the number of plants in the permanent quadrats dying of wilt could be made by comparison. Further, to see if the stand reduction was reflected in the yields from year to year, the yields for a seven-year period of the plats upon which the quadrats were located were obtained thru the

TABLE 1.—*Analysis of the permanent six-foot quadrants in plats of regional strains of Common alfalfa located at the Experiment Station, Lincoln*

Strain	1927		1928			
	No. plants	No. plants per sq. ft.	No. plants	No. plants per sq. ft.	No. plants dead	Per-centage dead
Argentine	23	.64	21	.58	2	8.7
Spanish	25	.67	14	.39	11	44.0
Italian	60	1.69	36	1.00	24	40.0
Russian	72	2.00	38	1.06	34	47.2
Texas	52	1.44	35	.97	17	32.7
Oklahoma	64	1.78	50	1.39	14	21.9
Kansas	81	2.25	63	1.75	18	22.2
Nebraska	79	2.19	66	1.83	13	16.4
South Dakota	69	1.92	61	1.69	8	11.6
North Dakota	59	1.63	50	1:39	9	15.2

TABLE 2.—*Analysis of wilt infection in the two-foot quadrats in plats of regional strains of Common alfalfa located at the Experiment Station, Lincoln*

Strain	1927				1928			
	Number of plants			Percent-age of healthy plants	Number of plants			Percent-age of healthy plants
	Healthy	Dis-eased	Dead		Healthy	Dis-eased	Dead	
Argentine	0	3	0	0	3	0	0	100
Spanish	0	2	0	0	1	1	0	50
Italian	0	3	1	0	1	1	0	50
Russian	6	5	2	46	3	5	4	25
Texas	0	6	0	0	1	8	0	12
Oklahoma	0	6	0	0	0	4	0	0
Kansas	1	12	6	5	0	8	2	0
Nebraska	0	11	5	0	1	7	2	11
South Dakota	2	20	0	10	2	13	3	11
North Dakota	1	14	0	7	3	9	5	18

courtesy of the Agronomy Department. Thus the problem of stand reduction due to wilt was approached from three avenues. Some of the results are presented for a number of plats.

Regional strains of Common alfalfa. In Table 1 is given an analysis of the six-foot permanent quadrats of ten regional strains of Common alfalfa. It can be noted that in 1927 the number of plants per square foot was rather small and varied somewhat in the quadrats. In all instances the number of plants per square foot was reduced in 1928 and the percentages of dead plants were quite variable. In Figures 4 and 5 the stands in 1927, with the number of dead or missing plants recorded in the spring of 1928, are graphically presented.

An analysis of the two-foot quadrats listed in Table 2 shows that from the standpoint of infected plants, all strains are susceptible to a high degree. In 1927, with one exception, from 90 to 100 per cent infection occurred. The number of infected plants found in 1928 is somewhat reduced due to some of the diseased plants failing to survive the winter, but, with few exceptions, a high percentage was found in the quadrats. It can be noted that no infected plants were found in the Argentine quadrat in 1928. As a rule, wilt does not attack every plant in a field and usually there are individuals which escape the disease. Thus, when very few plants are left in a field, some of them may remain healthy. Judging from these results, it is apparent that all regional strains of Common alfalfa studied are susceptible to wilt.

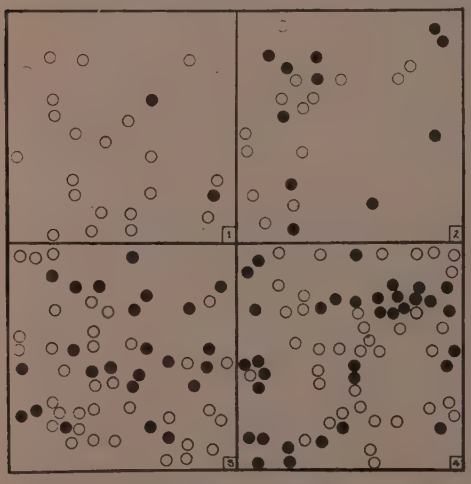

FIG. 4.—Number of plants (circles) in the permanent quadrats in 1927, with the number missing or dead (solid circles) in 1928, on four plats of foreign strains of Common alfalfa. 1.—Argentine. 2.—Spanish. 3.—Italian. 4.—Russian.

The yields of all strains, with one exception, were more than five tons of hay per acre during the first three

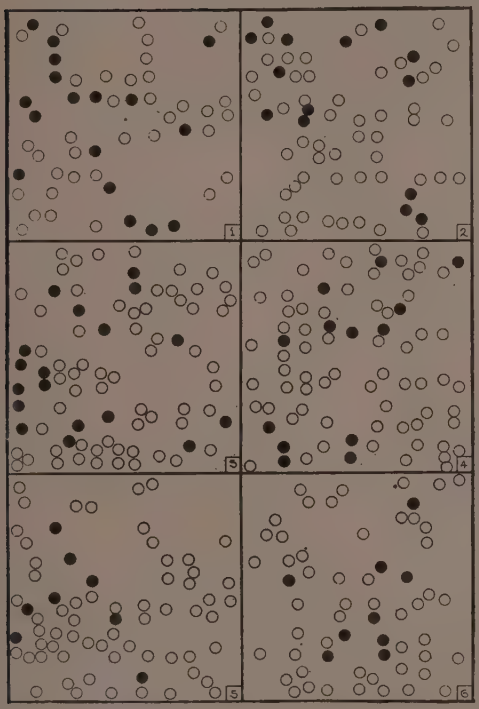

FIG. 5.—Number of plants in the permanent quadrats (circles) in 1927, with the number missing or dead (solid circles) in 1928, on six plats of regional strains of Common alfalfa. 1.—Texas. 2.—Oklahoma. 3.—Kansas. 4.—Nebraska. 5.—South Dakota. 6.—North Dakota.

years (Table 3). During the last four years the average yield of all unhardy sorts dropped below two tons per acre, whereas the more hardy ones had an average yield of more than two tons. The marked decrease in yield following the 1925 crop has been attributed by Kiesselbach, Russel, and Anderson (6) to depletion of subsoil moisture.

The stand reduction prior to 1926 due to winter injury is not reflected in the yields of the various strains. However, some wilt was found in the plats in 1925 and a higher percentage of infected plants was observed and recorded each succeeding year. The reduction in stands is reflected to some extent in the yields of the last four years, particularly in the plats of the unhardy strains, and has been due to winter injury plus the added factor of wilt. Altho all the regional strains of Common alfalfa appeared to be susceptible, the stand reduction of the unhardy sorts was greater owing to the facts that (a) they are more subject to winter injury, (b) the bacteria have access to more plants thru winter injury lesions, and (c) infected plants are more easily killed by low temperatures.

TABLE 3.—*Comparative yields of regional strains of Common alfalfa—Experiment Station, Lincoln* [1]

Strain	Av. yield 1923-29	Av. yield 1923-25	Av. yield 1926-29
	Tons	*Tons*	*Tons*
Argentine	2.92	5.25	1.32
Spanish	2.49	4.01	1.49
Italian	3.24	5.46	1.73
Russian	3.51	5.92	1.78
Texas	3.43	5.68	1.93
Oklahoma	3.43	5.68	1.94
Kansas	3.74	5.91	2.15
Nebraska	3.65	5.61	2.22
South Dakota	3.76	5.72	2.33
North Dakota	3.63	5.62	2.22

[1] The yields are based on weed-free hay containing 15 per cent moisture and are weighted on a percentage basis in accordance with average of nearest checks. Results from the above plats are reported for the period 1923-1926 in Nebr. Agr. Exp. Sta. Bul. 222. Subsequent yields are unpublished data furnished by the Agronomy Department.

TABLE 4.—*Analysis of the permanent six-foot quadrats in plats of alfalfa varieties located at the Experiment Station, Lincoln*

Variety	1927		1928			
	No. plants	No. plants per sq. ft.	No. plants	No. plants per sq. ft.	No. plants dead	Percentage dead
Turkestan	117	3.25	113	3.17	4	3
Hardistan	176	4.89	.....	.....	.....	.....
Provence	77	2.14	69	1.92	8	10
Grimm	140	3.89	125	3.47	15	10

TABLE 5.—*Analysis of wilt infection in the two-foot quadrats in plats of alfalfa varieties located at the Experiment Station, Lincoln*

Variety	1927				1928			
	Number of plants			Percentage of healthy plants	Number of plants			Percentage of healthy plants
	Healthy	Diseased	Dead		Healthy	Diseased	Dead	
Baltic	2	24	2	7	7	9	8	29
Cossack	1	14	7	5	7	11	1	37
Canadian Variegated	0	7	0	0	0	6	4	0
Neb. Common	1	15	3	5	4	10	0	40
Turkestan	16	1	5	73	6	6	0	50
Hardistan	9	13	0	41	10	4	2	56
Provence	10	4	0	71	10	1	0	91
Grimm	2	17	2	10	6	12	0	33

Alfalfa varieties. Permanent quadrats were located in plats of only four varieties (Table 4). Of these four, three had a much better stand than the regional strains of Common alfalfa (Table 1), as judged by the number of plants per square foot. Hardistan (5) was the most outstanding in this respect, having an average of almost five plants per square foot. Unfortunately, the stakes locating the permanent quadrat in this plat disappeared during the winter, so that it could not be relocated in the spring of 1928. Thus, the data for Hardistan are incomplete. During the winter, very few plants died in the Turkestan quadrat, a few more died in the Provence, and the greatest number in the Grimm quadrat (Fig. 6).

When the two-foot quadrats were analyzed, it was found that five out of eight varieties showed as great a percentage of wilt as Common alfalfa (Table 5). The three varieties which had a much lower percentage of wilt were Provence, Hardistan, and Turkestan.

The average yield (Table 6) of all varieties for the first three years was five tons or more of hay per acre. The yields obtained the last four years were not only more or less uniform but were about the same as those of the hardy regional strains of Common alfalfa. The hardy varieties which had a high percentage of wilt yielded as well as those with a low percentage of diseased plants, so that stand reduction due to wilt was not reflected in the yield data. The lack of subsoil moisture resulted in a slow growth of the plants and probably

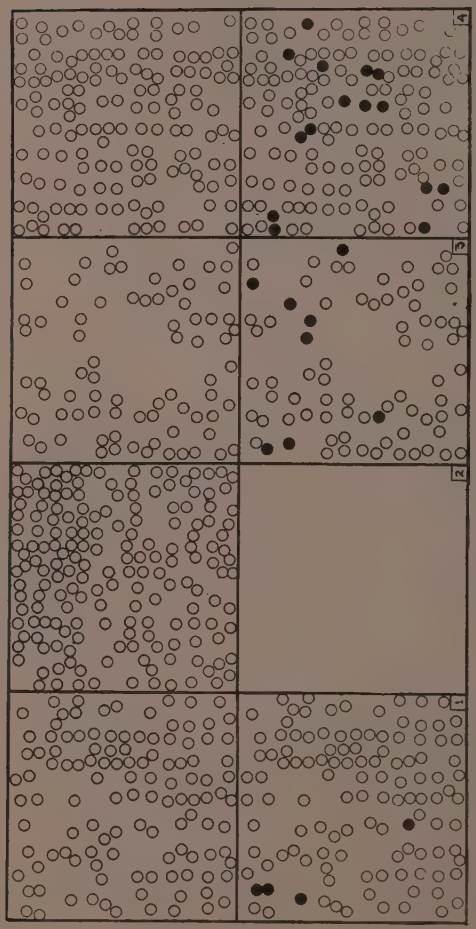

FIG. 6.—Number of plants (circles) in the permanent quadrats in 1927 (upper) and in 1928 (lower) with missing and dead plants (solid circles) on four plats of alfalfa varieties. 1.—Turkestan. 2.—Hardistan (quadrat could not be relocated in 1928). 3.—Provence. 4.—Grimm.

inhibited the rapid development of wilt. At any rate, development or increasing severity of wilt in susceptible but hardy strains or varieties of alfalfa under upland conditions is not rapid.

Thus, for the upland region of Nebraska, where alfalfa is used in rotation, while some of the hardy and high-yielding strains and varieties are susceptible to wilt, they can still be profitably grown for the reason that stand reductions due to wilt are not usually rapid or severe. Turkestan, Provence, and Hardistan have the added merit of wilt tolerance and when seed of the sorts reported on is available, they may be used to replace the wilt-susceptible varieties and strains where a stand over a long period is desired (Fig. 7).

TABLE 6.—*Comparative yields of alfalfa varieties, Experiment Station, Lincoln* [1]

Strain or Variety	Average 1923-29	Average 1923-25	Average 1926-29
	Tons	*Tons*	*Tons*
Baltic	4.07	5.92	2.69
Cossack	4.13	6.08	2.66
Canadian Variegated	3.52	5.53	2.01
Nebraska Common	3.68	5.36	2.42
Turkestan	3.50	5.00	2.38
Hardistan	3.83	5.47	2.59
Provence	3.31	5.15	2.23
Grimm	3.85	5.62	2.53

[1] The yields are based on weed-free hay containing 15 per cent moisture and are weighted on a percentage basis in accordance with average of nearest checks. Results from the above plats are reported for the period 1923-1926 in Nebr. Agr. Exp. Sta. Bul. 222. Subsequent yields are unpublished data furnished by the Agronomy Department.

FIELD STUDIES OF WILT IN BUFFALO AND DAWSON COUNTIES

During the spring of 1927, a survey of the alfalfa fields in the subirrigated sections of Buffalo and Dawson counties was made and a total of 29 locations were chosen in various fields for further observation. The histories of these fields were obtained from the growers and checked insofar as it was possible while they were under observation. After one season's study a number of these fields were plowed under be-

cause of unproductive stands. Similarly, the next year other fields were also plowed under, so that only six fields remained for observation the third season.

Permanent six-foot quadrats (areas of 36 square feet) were staked out in the most representative part of each of a number of fields. Each plant in the several quadrats was charted for a period of three seasons, or until the field was plowed under. In the vicinity of the permanent quadrats, two-foot quadrats (areas of four square feet) were dug at frequent intervals during the growing season and the percentages of

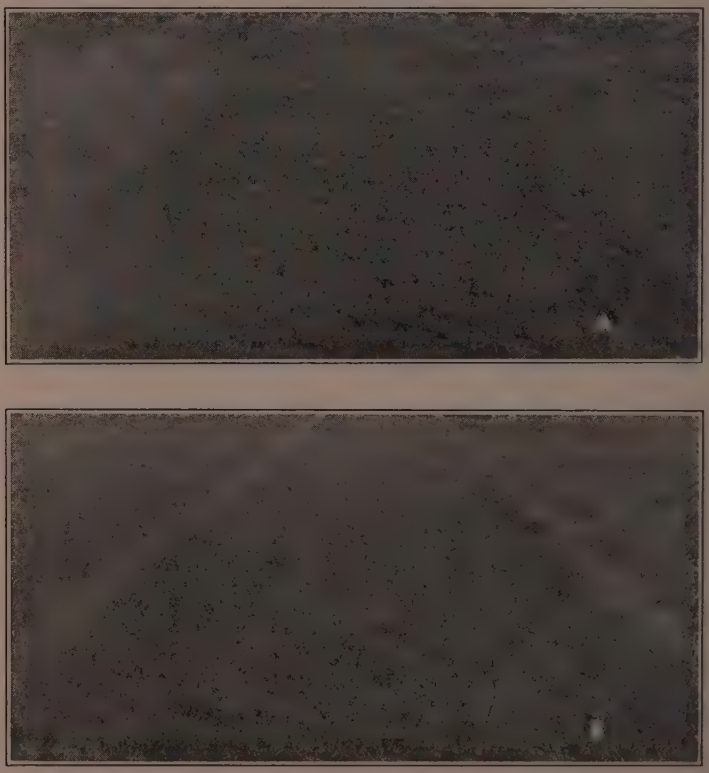

FIG. 7A.—A few of the plats at the Experiment Station, Lincoln, upon which permanent quadrats were located, showing stands at the end of eight years. (Photographed October, 1929.) A.—Provence center, Italian at left, Spanish at right. B.—Hardistan center, Nebraska Common at left, West Nebraska Common at right.

infected individuals ascertained thru the typical discoloration produced by the wilt organism.

A brief history and the results obtained in five typical fields of Common alfalfa which were plowed under in 1928 are given below.

Field No. 1. Common alfalfa, planted in 1918. About 17 feet to water. Estimated at half a stand. Field usually cut four times a year. Plants from two-foot quadrats, excavated during the summer, fall, and spring months, showed 52, 78, and 100 per cent infection respectively, with varying degrees of wilt

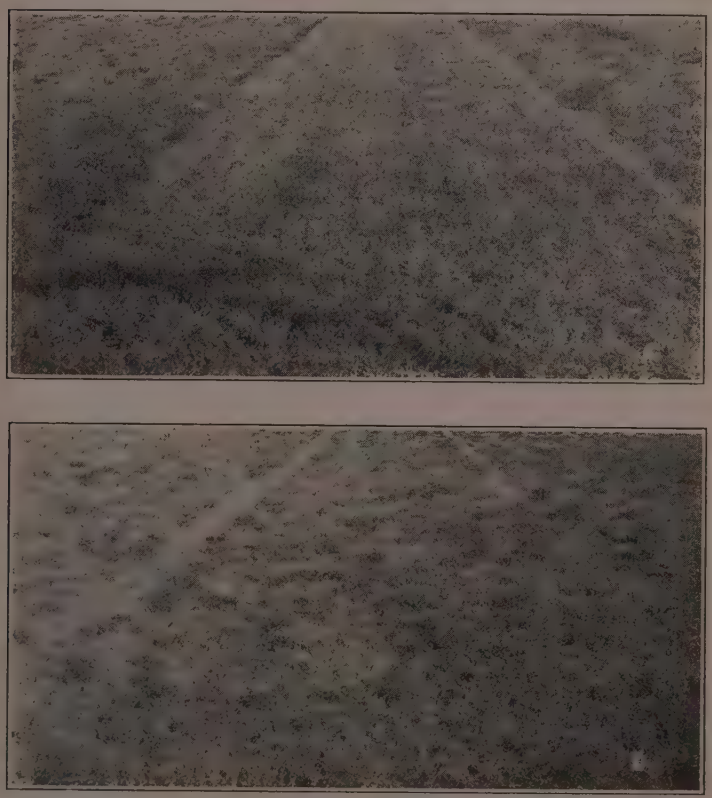

FIG. 7B.—A few of the plats at the Experiment Station, Lincoln, upon which permanent quadrats were located, showing stands at the end of eight years. (Photographed October, 1929.) C.—Turkestan center, Cossack at left, Nebraska Common at right. D.—Baltic center, Nebraska Common at left, Grimm at right.

symptoms. A 72-per cent loss of stand as measured by the difference in the number of plants in the two-foot quadrats during the summer and in the early spring occurred. With half of a stand present in June, 1927, approximately 72 per cent of the plants were killed by April of 1928, owing to the ravages of wilt and the death of infected and weakened plants during the winter. The field was plowed under in late April, 1928.

Field No. 2. South Dakota No. 12, planted in 1923. Grown adjacent to Common alfalfa (Field No. 1). Both fields usually cut at the same time, irrespective of difference in age and strain. The stand was about four-fifths of normal in June, 1927, so that there was a pronounced difference in stand in these two fields. The quadrats were dug about 30 feet from those in Common alfalfa. While only 46 per cent of the plants were found infected in the two-foot quadrats during the summer, in the fall 87 per cent were diseased, and in the spring 80 per cent. The loss in stand between June, 1927, and April, 1928, was 61 per cent. Part of the field adjacent to the Common alfalfa was plowed under in late April, 1928.

Field No. 3. Common alfalfa, planted in 1921. About 15 feet to water. Estimated stand, fair or better. Field usually cut three times a year. The permanent six-foot quadrat, on high ground in best part of field, charted in June, 1927, showed 2.8 plants per square foot. Forty-six, 87, and 80 per cent respectively of the plants taken in the two-foot quadrats during the summer, fall, and spring months had wilt. The loss of stand in quadrats as measured by the difference between the number of plants found in the quadrats in the summer of 1927 and the number found in the spring of 1928 was 61 per cent. The field was plowed under in late April, 1928.

Field No. 4. Common alfalfa, planted in 1921. About 11 feet to water. Estimated stand, slightly less than half. Usually cut four times a year. Two years previously cut five times and stand started to go down the following year. Twenty-eight per cent wilt was found in the plants in the quadrats taken during the summer, while 90 per cent was found in the fall. The reduction in stand at the end of the fall of 1927 was 50 per cent. Field was plowed under in November, 1927.

Field No. 5. Common alfalfa, planted in 1921. About 19 feet to water. Estimated stand, fair. Field usually cut three times a year. The percentage of wilt in the summer, fall, and spring quadrats was 90, 94, and 79 respectively. The loss of stand for the season was 39 per cent. Field allowed to remain during the 1928 season, but was not productive.

The histories of these five fields are typical of the histories of many fields of Common alfalfa observed thruout the subirrigated section of the Platte and other large valleys in the state, namely fields four to six years old with stands of one-half or less, with the majority of the remaining plants diseased and with a very rapid dying rate of the infected plants. The progress of wilt in an alfalfa field is a cumulative one, in that the stands thin out and yields decrease more rapidly each

year. The history of field No. 2 is also typical of the histories of many others observed: young fields growing next to older, diseased ones go out more rapidly from wilt than old fields seeded at a distance.

In the spring of 1921, Mr. Alvah Hecht, then county agent of Dawson county, planted a series of plats of a number of alfalfas which had been recognized in his county as having special merit. The seed for these plantings was obtained from the following fields, which at the time the plats were planted were outstanding and productive: the Lansing field (planted in 1908), the Hiles (planted in 1893), and the Arnold (Hardistan) (5), (planted in 1911). Common, Grimm, and Turkestan were included in the test. As a rule the field which included the plats was cut four times a year. In the spring of 1927 a fair stand was present in all the plats. Shortly after observations were begun on these plats, hogs were turned into the field. However, observations were continued for a period of a year. Since the field was used for a pasture during the season, the results are not so comparable as might have been expected. However, they do show some consistent differences.

TABLE 7.—*Percentage of wilt and loss in stand as determined from the two-foot quadrats in test plats planted in Dawson county in 1921*

Variety or Strain	Summer Months 1927		Fall Months 1927		Spring Months 1928		Average percentage of wilt	Percentage of loss in stand
	Total number of plants	Percentage of wilt	Total number of plants	Percentage of wilt	Total number of plants	Percentage of wilt		
Common	43	67	31	74	17	76	72	60
Lansing	27	74	17	94	10	90	86	63
Hiles	34	70	23	100	11	63	78	68
Hardistan	39	61	33	81	22	54	65	43
Turkestan	39	51	33	60	28	14	42	28
Grimm	44	70	35	86	18	67	74	59

By means of two-foot quadrats, the percentage of wilt was determined for the summer and fall months of 1927 and the spring months of 1928. The loss of stand was measured by the difference in number of plants found in the quadrats in the summer months of 1927 and the spring months of 1928. In spite of the rather rigorous pasturage received by these plats during the time observations were continued, the results (Table 7) show that from the standpoint of percentage of wilt and loss of stand, Arnold (Hardistan) and Turkestan are

more tolerant of wilt than the others, which are more susceptible to wilt and suffered a greater reduction in stand.

During the summer of 1927, two-foot quadrats were dug at intervals on three fields of Grimm, Common, and Turkestan, which were then in their second season of growth. Only one infected plant was found in the several quadrats in Grimm alfalfa during 1927, while infected plants scattered here and there were found in greater numbers the following year. Similarly, only one infected plant was found in the field of Common alfalfa during 1927. However, 7 per cent of those dug in the spring of 1928 were infected and almost 40 per cent during the fall months, so that the spread of wilt was apparently very rapid. This two-year-old field was in close proximity to an older, badly infected field, while the Grimm was not located near an infected field. In the Turkestan quadrats only one infected plant was found during 1927, 4 per cent in the spring, and 9 per cent in the fall of 1928—not at all a rapid spread of wilt, even tho it was adjacent to an infected field.

Only one field was so badly infected with wilt at the end of the second year that it was plowed under the following spring. This field was planted to Grimm alfalfa and irrigated. The field was so situated that the irrigation water and all the surface drainage from an older and badly infected field flowed from this old field to the younger seeding.

The contours of one field provided for a number of observations on surface drainage and its influence on the spread and development of wilt. The history of the field is as follows:

Field No. 6. Common alfalfa, planted in 1921. Seed from an old field grown on the farm. Water table about 19 feet. Usually cut three times a year. Stand fair to good over the field as a whole. Several natural, fairly wide drainways running thru the field. Stand on higher ground almost perfect, while in drainways only fair and quite variable. No apparent loss in stand prior to 1926.

Permanent six-foot quadrats were located on typical higher ground and in one of the wide drainways. Two-foot quadrats were dug in the vicinity of the larger quadrats during the growing season in 1927 and 1928.

By the summer of 1927, as is shown in Figure 8, only 3.11 plants per square foot were found in the permanent quadrat on low ground, whereas in a similar quadrat on high ground 5.47 plants per square foot were present. Unfortunately, during the summer of 1927, part of the quadrat on high ground was dug up for the smaller quadrats. However, only 1.67 plants per square foot were found in the quadrat on low ground, a reduction of 46 per cent, while 4.18 plants per square foot were present in the quadrat on higher ground, a reduction of only 16 per cent. The permanent quadrat on low ground was read again in the spring of 1929 and only 1.11 plants per square

foot were found, a further reduction of 33 per cent. It can be readily seen that the plants on the low ground died much faster than those on the higher ground.

A comparison of the results of the two-foot quadrats dug at intervals during the year on low ground shows that 86 per cent of the plants were found infected during the summer months of 1927, 89 per cent during the fall months, and 78 per cent during the spring months of 1928, with an approximate loss in stand of 50 per cent; whereas, for these same periods, 24, 29, and 31 per cent of the individuals were found infected in the quadrats on the higher ground with a loss in stand of 28 per cent.

From these striking differences obtained in areas in one field not more than 75 yards apart, one must conclude that wilt not only spreads faster but the infected plants die more rapidly in the lower areas of infected fields.

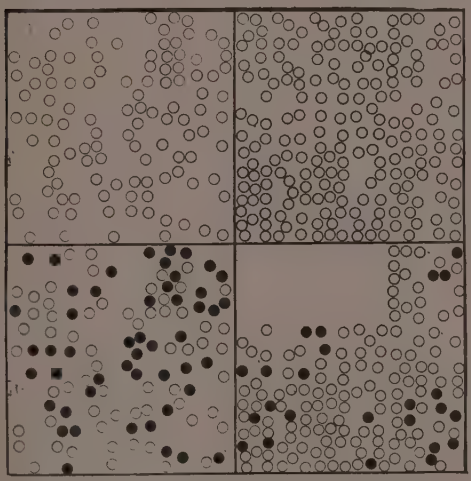

FIG. 8.—Number of plants (circles) in the permanent quadrats on low ground (left) and high ground (right), in 1927 (upper) and in 1928 (lower) with missing and dead plants (solid circles) in field No. 6. (The 1928 quadrat on high ground is not complete because the two-foot quadrats were dug in this same area in the late summer of 1927.)

Two fields of Grimm three and four years old were observed for a period of two years by means of the two types of quadrats. The histories of the fields follow.

Field No. 7. Certified Grimm, planted in 1924. About 18 feet to water. Estimated stand, good altho in June, 1927, evidences of wilt symptoms were very plentiful. The permanent six-foot quadrat read in July of the same year showed 238 individuals, or 6.61 plants per square foot. A year later in the same quadrat only 26 per cent were living, or 1.75 plants per square foot—a reduction of 74 per cent or 4.86 plants per square foot, truly an enormous reduction of stand for one year (Fig. 9).

The two-foot quadrats dug during the summer and fall months of 1927 had 40- and 82-per cent-diseased plants, while 100-per cent-infected plants were found in the quadrats dug in

the spring of 1928. Wilt was apparently the primary factor responsible for the stand losses in this field and the results seem to show here again that Grimm is quite susceptible to wilt.

Field no. 8. Grimm alfalfa, planted in 1923. About 17 feet to water. Estimated stand, spring of 1927, 75 per cent. The permanent six-foot quadrat had 3.28 plants per square foot in June, 1927. A year later only 40 per cent of the plants remained in the quadrat, a total reduction of 60 per cent, or 1.94 plants per square foot, leaving slightly over one plant per square foot. The field was plowed under in the fall of 1928 (Fig. 9).

The two-foot quadrats dug during the summer and fall months of 1927 had 42- and 88-per cent-diseased plants, while 82 per cent were found in the quadrats dug during the spring of 1928. While this field was one year older than field No. 7, the results are very much the same.

In contrast to these two fairly young Grimm fields, two other fields of other sorts are cited at this time.

Field No. 9. Turkestan alfalfa, planted in 1921. About 17 feet to water. Estimated stand, fair to good. This field was adjacent to a field of Common alfalfa which, in the spring of 1927, had almost died out from wilt. No wilt symptoms were observed in the Turkestan alfalfa prior to 1926. Both fields were cut together, three or four times a year. In 1927 the permanent quadrat had 3.5 plants per square foot; in 1928, 3.17 plants per square foot; and in 1929, 2.84 plants per square foot. Only 20 per cent of the plants died in the quadrat during a period of two years (Fig. 9), of which only 9 per cent died the first winter. Two-foot quadrats dug during the summer and fall months of 1927 and the spring months of 1928 had 42-, 58- and 33-per cent-diseased plants with little or no difference in stands.

Field No. 10. Seed of unknown origin, planted in 1908. Consisted of a strip approximately 20 yards wide thru the field. This alfalfa showed some characteristics of Turkestan. Alfalfa of other sorts had been replanted two and three times adjacent to this strip. The Common alfalfa lying directly to the south and west was plowed under in 1928, while the very unproductive field to the north is still standing, altho plants are dying very rapidly with wilt (Fig. 10). Water table about 16 feet. Estimated stand in 1927, 75 per cent, and from the standpoint of resultant yields, 90 per cent.

In 1927 the permanent quadrat had 2.86 plants per square foot; in 1928, 2.03 plants per square foot; and in 1929, 1.53 plants per square foot. The stand, while only averaging about 1½ plants per square foot, is productive and very few bare spots can be seen during the growing season (Fig. 9). Twenty-six, 36, and 40 per cent of the plants dug in the two-foot quadrat during the summer and fall months in 1927 and the spring months of 1928 were found infected with wilt. The contrast in age, stand, and susceptibility to wilt between these two fields and the two fields of Grimm are very marked.

FIG. 9.—Number of plants (circles) in the permanent quadrats for the years 1927, 1928, and 1929 with number of missing and dead plants (solid circles) found the last two years. 1.—Field No. 10 (planted in 1903 with seed of unknown origin). 2.—Field No. 7 (certified Grimm seeded in 1924). 3.—Field No. 8 (certified Grimm seeded in 1923). 4.—Field No. 9 (Turkestan seeded in 1921).

These field studies of stand reduction indicate that the severity and development of wilt vary with the variety of alfalfa. Both on the uplands and under subirrigation, Common alfalfa is susceptible to wilt in that a high percentage of infected individuals have been found in all fields observed. Stand reduction due to wilt varies, of course, with the age of the fields when infection first occurred, with the locations of these fields with respect to older, diseased fields, with the amount of winter injury present, with the cultural practices followed, and finally with the conditions under which the alfalfa is being grown.

At Lincoln, on the uplands, it was found that three sorts were tolerant to wilt. These were Hardistan, Turkestan, and Provence. Grimm, on the other hand, appeared to be as susceptible as Common alfalfa. In the subirrigated region, Hardistan and Turkestan appeared to be quite tolerant to

FIG. 10.—The dividing line between field No. 10 and Common alfalfa. The Common had been replanted for the third time since the hardy and wilt-tolerant field was seeded in 1908. (Photographed June, 1927.)

wilt, while Common and Grimm were susceptible. The severity of wilt was much more pronounced in this region than in the uplands, especially with Grimm and Common alfalfa.

Unfortunately, no detailed studies were made in the western part of the state, in the irrigated sections, and on the tablelands. Only one field under irrigation was under close observation in central Nebraska. It happened that this field was so situated that a large source of infection in the form of an old, diseased field was at hand, so that the stand losses were so severe at the end of the second season that the field had to be plowed under. Quadrats dug in September, 1928, over

the field yielded almost 100 per cent of infected plants. Stand reductions in Nebraska alfalfa fields, due to wilt irrespective of other factors, have been found to vary from most to least rapid in the following sequence: under irrigation, under subirrigation, on eastern uplands, and on the western tablelands.

LENGTH OF LIFE OF INFECTED PLANTS

On December 3, 1926, a number of diseased plants five years of age were brought into the greenhouse and the roots cut to a uniform length. They were then grouped into three lots, according to the amount of discoloration present at the cut ends. The plants were potted and allowed to grow in the greenhouse until they died. It was found that plants with slightly discolored roots lived for about nine months, with moderately discolored roots about five to six months, and with severely discolored roots only about two to three months.

Under field conditions, however, so many factors enter in that it is difficult to determine the actual length of life of diseased plants. Plants have been observed which were infected in the early part of the growing season and died before fall. Other plants have been found which had two, occasionally three, and rarely four rings of discoloration, showing that they were able to develop and persist in spite of wilt infection for several years. In fact, plants have been found that have apparently outgrown the disease.

Based on numerous observations, in many fields growing under varied conditions, made during the past three years, it can be stated that apparently the majority of plants die at the end of the second season after infection. That is, plants infected in the spring of one year produce a ring of discoloration, live thru the winter, and die sometime during the second season. However, a small percentage live thru until the third season, as evidenced by plants having two distinct rings of discoloration. Thus, the length of life of diseased plants is extremely variable, owing first of all to extreme variations in the growth of the individual plants, and, second, to the resultant of all environmental factors tending to accelerate the death of the plants. No doubt many of the plants weakened by the disease succumb from low temperatures during the winter. However, it can be stated that the greatest loss of plants from wilt occurs during the second season after infection, especially at the time when the plants are under great stress, namely, during the period of high temperatures, hot winds, lack of precipitation, and high rates of transpiration.

AGE OF PLANTS INFECTED WITH WILT

In the fields only a few plants have been found that were infected during the first season's growth. Seedings made in

August on old alfalfa wilt-infested land have been found infected the following April. Similarly, seedings made in April in an old, thin stand of alfalfa, badly diseased by wilt, did not show any infection during the first season. Diseased plants, however, were found the following spring.

Plants are generally attacked by wilt in the field at any age from the second year onward. Old plants, seeded in 1893, have been repeatedly found showing very recent infection, as determined by very slight discoloration in the new wood. Thus, in most fields two years old or older, diseased plants can be found infected at different times. In the old field mentioned above, all types occur from those recently infected to plants which somehow recovered from the disease ten years previously.

While in the field only a few plants have been found infected during their first season's growth, 60-day-old seedings have been successfully infected in the greenhouse by inserting bits of tissues from diseased plants just under the bark. Likewise, plants seeded in May and dug, inoculated, and transplanted in the greenhouse in the fall, produced typical symptoms of wilt 60 days after they were inoculated. The infection of young plants during the first season in the field is probably rare.

In this connection, the history of some variety test plats, seeded under different conditions in the Platte Valley in Buffalo and Dawson counties, might be included here, in order that the age of the plants at the time of first infection of a new field can be correlated to some extent with the conditions which favor such infection.

Series No. 1. In alfalfa continuously for 30 years until 1926. In corn during 1926. Seeded to the variety tests May 1, 1927. No wilt was found in these plats until the third spring when an occasional plant was found. By fall diseased plants could be more readily observed.

Series No. 2. In alfalfa for 19 years. Alfalfa sod (rather thin stand, badly infected by wilt) broken up and seeded to the variety tests in May, 1927. Plants have not yet reached the water table and are making an extremely slow growth. No wilt had been found in these plats up to the fall of 1929, in spite of the fact that the seeding was made on wilt-infested land and the plats have been cut along with other alfalfa showing wilt in the same field.

Series No. 3. Land never in alfalfa. Plats seeded in April, 1927. No wilt had been found up to the fall of 1929.

Series No. 4. Land cropped to corn and potatoes for past seven years. Seeded in May, 1927. Wilt in small amounts was found during the second season, while in 1929 wilt had increased rapidly and could be readily observed. While no alfalfa had been grown on this land for seven years, badly wilt-infected

alfalfa was growing adjacent to these plats and was mowed along with this field.

Series No. 5. Had not been cropped to alfalfa. Land located in the uplands, typical of a large acreage of alfalfa in Buffalo county away from the valley. Plats seeded in April, 1927. No infected plants have as yet been found in these plats.

The early history of these variety plats shows that the time of infection of the new plantings varies considerably with the previous crops, environmental conditions, and the nearness of infested fields. Where the land has never been cropped to alfalfa, wilt has not been found at the end of the third year. On the other hand, where alfalfa sod was plowed under, cropped with corn for one year, and then reseeded to alfalfa, wilt was found in small amounts at the beginning of the third year. New seedings, made on land not cropped to alfalfa for several years but with an infected field growing in close proximity, developed sufficient wilt in the nearest plats so that typical symptoms were observed the second year. However, a second series of plats on old, infested alfalfa ground and also adjacent to an old field had no diseased plants at the end of the third season, due perhaps to the slow growth of the plants because of lack of available soil moisture. Thus, the age of plants in a new field when wilt attacks them varies with conditions, but once wilt is present, plants of any age can be infected.

TIME OF INFECTION

The time of infection has been studied thru field observations during the growing season, with fresh material sectioned with a freezing microtome, with embedded material, and thru inoculations made during the growing season. The study of process and time of infection discussed in the following pages has been based on all four modes of approach.

Many observations have shown that there are two periods during the growing season when the majority of the plants are infected. It can be stated with some definiteness that much of the infection occurs at the time of the first cutting, the forepart of June. In order that this may be made clear, the development of the bacteria in an infected plant must be explained. In determining the number of bacteria in the stems of infected plants it has been found that large numbers of them are found in the first growth in the spring. The number of bacteria apparently decreases in the stems of the second growth and fewer bacteria have been found in the stems of the third and fourth cuttings.

In the fall, many bacteria have been found in the newly formed buds where they presumably remain during the winter.

With the resumption of growth, the bacteria probably move up as the buds develop into stems. When the field is mowed the forepart of June, the bacteria from the diseased stems in all probability contaminate the cutting bar of the mower and enter the cut ends of stems of healthy plants. June, in Nebraska, is usually a month with high rainfall in the form of numerous showers, and it is not at all infrequent that alfalfa growers have trouble putting up hay. Thus, environmental conditions are very favorable for the spread of bacteria and infection thru the cut ends of stems at this time.

A series of meter-square plats were laid out at Lincoln in 1929 in Grimm and Common alfalfa planted in the spring of 1927. Every two weeks, beginning May 8, a section was sprayed with a suspension of the organism and cut so that the tool and plants were well moistened with the suspension. A similar meter-square area was sprayed with water and cut in a like manner. On November 11, one-half of all the areas, both controls and inoculated, were dug up and the roots examined for discoloration. It was found that the highest percentage of infection occurred in those plats inoculated during the last half of May and forepart of June, altho an occasional plant was found with discoloration in those inoculated later. The results indicate that infection takes place readily in late May and the forepart of June.

The second period when infection is likely to occur is in the early spring and probably is brought about thru wounds caused by winter injury. For example, in the Platte valley, March, 1928, was characterized by mean temperatures well above normal, whereas April was cold and below normal. In fact the minimum temperature at Kearney was below 32° F. on fourteen successive days during the first half of the month. During March, growth of the plants was resumed, but in April considerable winter injury was found to have occurred. These fresh openings in the plants may have provided the portals for the bacteria to infect many plants.

When the data from the two-foot quadrats obtained from all the fields under observation in the Platte valley were summarized, they showed that in 1927 a high percentage of the plants were infected at the time of first cutting, while in 1928 many of the plants were infected in April, when winter-injury wounds were formed. Some early spring infection took place thru winter-injury wounds in 1927 and infection also occurred in 1928 at the time of the first cutting. The relative importance of these two periods of infection would depend largely on the number of winter-injury wounds produced in the spring and on the environmental conditions prevailing at the time of the first cutting.

While the periods discussed above probably are the two most important, this does not preclude the possibilities of infection at other times. No doubt some infection does take place during the summer; observations indicate that it is relatively rare in the fall.

METHODS OF ENTRANCE OF THE BACTERIA INTO THE PLANTS

While considerable work has been done on the pathological anatomy of alfalfa wilt during the past three years, all details in the sequence from entrance, development in the tissues, and the release of the bacteria from dead or diseased plants have not been entirely clarified. For this discussion, however, it is sufficient to state that the bacteria, not being able to enter an uninjured and healthy plant, find openings at two points, which are responsible for the majority of diseased plants.

The first entrance is likely to take place in the early spring thru cracks and other wounds caused by winter injury. Entrance of the bacteria perhaps is effected before the injured tissue begins the formation of wound tissue. Once entrance takes place, the bacteria migrate to the vascular elements and invade the water-conducting system, where the organism multiplies rapidly in the pits of the vessels. The bacteria are carried up and down and around thru the anastomosing vessels to the crown and stem and various parts of the plant. The typical discoloration by which the disease is recognized, is produced thru the formation of a gum by the host as a result of bacterial invasion. Somewhat later the bacteria escape from the vessels, invade the parenchyma, and finally reach the phloem or bark. Here a breaking down of the invaded tissues occurs, which results in pockets filled with bacteria. Generally a plant does not succumb until the cambium is destroyed in whole or in part. The bacteria in the pockets are released by the breaking down of the outer bark. A detailed discussion of the pathological anatomy of alfalfa wilt will be presented in full at a subsequent date.

Observations indicate a definite relationship between winter injury and the bacterial invasion of a plant. However, the mechanics of winter injury have not been fully studied. A study is now under way on winter injury in cooperation with the Office of Forage Crops and Diseases, United States Department of Agriculture, and a complete discussion of the relation between winter injury and invasion of the plant thru the resulting wounds by the bacteria must be postponed until a later time.

The second avenue of entrance is very likely thru the cut stems at the time of mowing and especially during the first cutting. The cutting bar, as it passes over plants, may carry

the bacteria from diseased to healthy plants and entrance of the bacteria probably takes place simultaneously with the act of cutting. Very little or no infection takes place after the stems are cut because the exposed tissues dry up very quickly and the bacteria are not able to develop unless they are in direct contact with living tissue. After entrance, the bacteria immediately invade the conducting tissues and move downward into the crown and root tissues where they develop as previously noted. No doubt the bacteria are able to enter thru other types of wounds, but the two portals of entrance described are considered the most important.

METHODS OF SPREAD OF THE BACTERIA

Apparently there are two important means by which the organism can be carried from plant to plant and from field to field, namely surface, irrigation, or drainage water and the cutting bar of the mower. No doubt there are other means by which the organism can be dispersed, but in all probability they are not so important or so easily detected as the two mentioned above.

Water of any origin carrying the bacteria released from the diseased plants is particularly important in the early spring at the time growth is being resumed, for it is at this time that many of the winter-injury wounds are produced. It has been repeatedly observed that the disease is usually more prevalent and serious in low places in the field and along natural drainways. (See history of field No. 6.)

As pointed out previously, while infection can occur during the summer months, many of the plants in the field are probably infected at the time of the first cutting by the cutting bar of the mower. At the time of the first cutting, environmental conditions such as wet soil, dew, and rainy weather are usually very favorable for the spread of the organism.

It has been noted in many instances that when a diseased field is located above a young field there is more likelihood of its being infected, not only earlier in its life but also more generally. Similarly, where a young field is adjacent to a diseased field and the two fields are mowed as a unit, the incidence of infection is increased. (See histories of field No. 2 and Series No. 4.)

The length of life of the bacteria in the soil has not been determined. All tests so far have been negative, probably owing to the difficulty in recovering the organism, which grows very slowly. Likewise, all isolations from dead plants left in the field over winter have yielded negative results, so that the length of life of the bacteria outside of the host plant is unknown.

A large number of isolations from seed obtained from diseased plants have also been negative. The organism has not thus far been obtained from seed, even when seeds were taken from severely diseased plants. However, this does not preclude the possibility that the organism is seed-borne.

VARIETAL RESISTANCE

Not enough data have been accumulated to support a definite statement regarding varietal resistance in alfalfa. Field observations in various parts of the state on stand reduction with a number of varieties, however, indicate that from the standpoint of wilt alone, all regional strains of Common alfalfa studied are susceptible. All field observations of Grimm indicate that it is equally as susceptible as the Common alfalfa.

Three varieties have been shown to be quite tolerant of or resistant to wilt; they are Turkestan, Provence, and Hardistan. However, tests have been made on only three introductions of Turkestan and until tests have been completed with Turkestan seed from various sources, nothing definite can be said regarding this variety in general and its resistance to wilt. The same can be said for Provence. Hardistan, on the other hand, has originated in one field in Nebraska, so that the source of the seed is well known. Hardistan has yielded as well as Common and other varieties and appears to be quite tolerant of wilt. A number of daughter fields grown in the Platte valley have been located and in every instance they have maintained their stands and shown much less wilt than Common alfalfa grown under the same conditions. However, it will be several years before enough seed of Hardistan will be available for general planting in Nebraska. A number of varieties are now being tested in several localities in Nebraska, so that within the next few years their reaction to winter injury and wilt can be determined.

In this connection, a program of selection of desirable types of alfalfa plants from a number of old fields in Nebraska was undertaken in 1927. Thru the use of cuttings, a number of plants have been grown from a single mother plant and both open and self-pollinated seed have been obtained. It will be several years before these selections have been tested for hardiness, wilt resistance, and yields. The project is being carried on in co-operation with the Department of Agronomy of this Station and the Office of Forage Crops and Diseases, United States Department of Agriculture.

RECOMMENDATIONS

The fact that alfalfa wilt *(Aplanobacter insidiosum)* has been found thruout Nebraska in fields from two to 34 years

of age, growing under widely diverse conditions, indicates that alfalfa wilt is not a new disease, but one that has been recently recognized. It is perhaps true that losses from wilt in the past have been attributed to winter injury. Unlike other vascular diseases of bacterial origin, which, for the most part, attack annual crop plants, the progress of this disease is a cumulative one, in that starting with a few infected individuals in the field there is a progressive and rapid increase in the number until the field becomes unproductive. The seriousness of the disease depends in part on the variety or strain of alfalfa but particularly on the conditions under which it is grown.

Because the bacteria are unable to enter plants in the absence of wounds, any conditions responsible for the production of lesions must be avoided. Once the bacteria gain entrance, death of the plant ensues in time. Therefore, the final solution of the alfalfa wilt problem in Nebraska is the development of resistant varieties which are winter-hardy as well as productive. Until such varieties are available to the alfalfa grower, there are a number of measures which can be suggested in attempting to reduce the losses from wilt to a minimum.

The use of hardy seed of known origin is one of the first measures that can be employed for the present. Hardy sorts, even tho they may prove somewhat susceptible to wilt, will maintain a stand for a longer period than non-hardy sorts. Those who wish to grow Turkestan should try a small acreage, for at present there is no way of knowing whether all Turkestan seed will behave as have two or three introductions thus far tested. The location of new seedings is quite important in that it is unwise to reseed on old alfalfa sod, even where conditions are favorable for this procedure. Further, new seedings are more easily and quickly infected when planted close to or below older, diseased fields.

After a stand of alfalfa has been obtained, all practices insuring the maintenance of this stand are worth while. It is highly essential to avoid mowing too late in the fall, as late mowing during occasional years when new growth is not resumed before low temperatures prevail, makes the plants more susceptible to winter-killing and injury in the spring. Any condition favoring the development of winter lesions in the early spring is to be avoided, as these lesions serve as a means of entrance for the bacteria.

In order to prevent the spread of the bacteria from field to field, it is desirable that all fields be mowed separately. It is preferable to begin operations on the younger and move to the older fields. In all instances it is quite essential to mow

only when the plants are comparatively free from moisture in the form of dew in the morning or after a shower. In short, any practice that will lessen the susceptibility of the plants to winter injury wounds in the early spring or reduce to a minimum the spread of the organism by water or the cutting bar of the mower, will assist in maintaining a stand of alfalfa against the inroads of wilt.

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